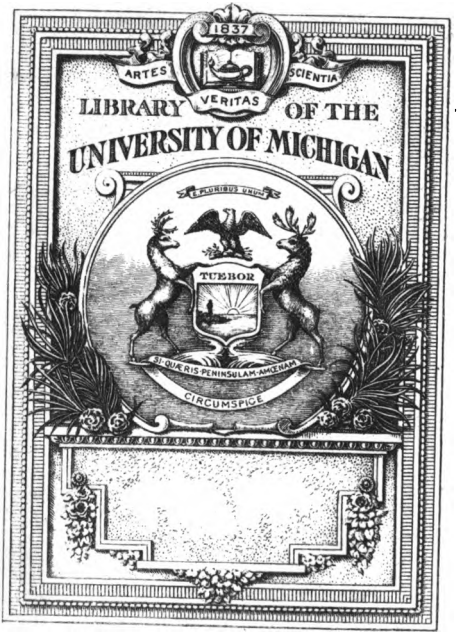
HOW TO MAKE PRINTS IN COLORS

PRACTICAL PHOTOGRAPHY SERIES

FRANK R. FRAPRIE



PRACTICAL PHOTOGRAPHY, No. 4

HOW TO MAKE PRINTS IN COLORS

Edited by
FRANK R. FRAPRIE, S. M., F. R. P. S.
Editor of "American Photography" *and*
"Popular Photograpy"

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HOW TO MAKE PRINTS IN COLORS

The Why of Colors. — There comes a time in the career of most amateurs in photography when, like Alexander sighing for more worlds to conquer, they wish for prints in colors. The beautiful black and white of gaslight paper no longer looks good to them. The inborn craving of human beings for that which is out of reach causes them to search the stockhouses and the catalogues for a paper which will give variety to their work by allowing them to make pictures in different colors. Perhaps they feel that a certain sea view with a yacht sweeping along with the wind on her quarter will appeal more strongly if rendered in blue or in sea green. A leafy woodland glade, with practically no color but green present in the real scene, looks more natural if printed on Velvet Green. A sketchy large head seems in somewhat the style of an old master, and if his example is followed and the print is made in red chalk, the resemblance is enhanced. Unlike Alexander, however, the amateur has his worlds yet undiscovered and lying ready to be conquered. Printing processes are legion, and some colors, at least, can be produced with such ease and certainty that we wonder so few workers set out on their expeditions to conquer those unknown regions which beckon so enticingly to the adventurer.

Half the pleasure of photography, for most of us, lies in the technical side of the work. Not only are pictures an end to be reached, but an absorbing interest lies in the mere making of them. Irrespective of the subject, each exposure is a mystery until the finished negative reaches the printing frame and the print tells the story of complete success or relative failure. If this is true of ordinary printing in black and white, how much more interest must lie in the endeavor to render each subject in the color most suggestive of the reality! And how we have longed for a perfect process of printing on paper in the actual colors of nature! Until now, however, when the dream seems to be coming true, we have had to content ourselves with prints in one color. For this, we can use a fairly large number of colors or tints and obtain some of them by many processes. But first let us quickly review the principles of color as they apply to pigments.

Primary Colors. — The painter deals with three primary colors, red, yellow, and blue. Although no perfect primary pigments exist, it is possible to select two pigments approaching each primary in such a way that each shall lean towards one or the other of the remaining primaries and thus secure, by mixing two or more, almost every conceivable tint. For instance, we may not be able to get a certain hue in a mixture by the use of a blue-red; but the yellow-red, or scarlet, may yield it exactly.

Pure yellow has so little body that it can hardly be seen when placed on white paper. It needs another color to bring it out by contrast. Pure red is almost as weak, for printing purposes. Blue alone has enough

vigor to be suitable for picture making. These statements apply to the pure primaries. Degraded colors, that is, those not free from admixture with others, such as red chalk and several other impure red tints, may answer very well.

Secondary Colors. — When two pigments of primary colors are mixed, the resulting color is called a secondary. Thus, blue and yellow make green; red and yellow make orange; blue and red, purple. For photographic purposes, orange is not very suitable, but the other secondaries are capable of giving good contrast with white paper and carrying all the details in the shadows so as to make a brilliant, satisfactory print. Purple tones, such as were obtained on the old glossy albumen and gelatine printing-out papers, were for years the only ones in favor among photographers.

Tertiary Colors. — When all three primaries are mixed, a tremendous variety of colors may be produced by varying the proportions of the primaries. The tertiary colors include olives, browns, etc. They are all satisfactory as photographic pigments. They are easily produced. Indeed, many workers find it almost impossible to get clean, neutral blacks, so strongly inclined to olives and browns are all the more popular gaslight papers. Years ago, a cold blue-black to pure black was considered the standard; but now, so strong is the craving for color, papers have been modified to introduce warmth of tone.

The Photographic Colors. — Considering only prints on paper, then, we may limit the discussion of colors to two primaries, blue and red; to two secondaries, green and purple; and to the olives and browns, in

many modifications and with only slight differences between them.

The Plan. — Long consideration of a scheme for treating each color separately brought us to the conclusion that it was impracticable, so we shall take up the different processes in order, giving full directions for working them and an account of the different colors which can be obtained with each. First, and simplest of all, let us consider the well-known blueprint process.

Blueprints. — Everybody knows the blueprint, much used by architects and engineers for the cheap duplication of drawings. Precisely the same process is employed for photographic printing. The paper, of a little better grade than that used by architects, is on the market, but the user can make his own paper easily and cheaply. The commercial product comes in tin tubes, to prevent moisture from spoiling the paper before use. The advantage of making one's own is that only sufficient for the work in hand need be coated at one time, thus avoiding waste and securing the best possible results. Fresh paper yields sharp, brilliant prints; stale paper, dull, lifeless ones.

The paper stock may be any sort which one fancies, though it is better to use Rives photographic raw stock, obtainable from the largest stockhouses, a good make of drawing paper, or a good linen ledger. Such papers do not need any preliminary treatment with a size. Smooth paper, naturally, gives better detail than the rougher sorts. The rendering of halftones is not perfect, so the best type of negative for blueprinting is one which has not much soft gradation, but is rather inclined to clear glass in the shadows and considerable intensity in the lights. The typical

amateur snapshot, somewhat undertimed and fully developed, usually gives good results on blueprint paper. Weak negatives yield flat, lifeless prints.

Blueprint Formula. — The best formula for the coating is

A. — Ferric-ammonium citrate (green scales)	110 grains
Water	1 ounce
B. — Potassium ferricyanide	40 grains
Water	1 ounce

Mix equal parts and keep in a yellow-glass bottle in the dark. Filter just before use. The green scales are much to be preferred, but if only the ordinary brown citrate can be obtained, 80 grains only should be used and the ferricyanide should be increased to 60 grains.

Coating the Paper. — Pin a sheet of paper to a suitable board and apply the sensitizer with a tuft of cotton, making the strokes one way until the whole surface is covered, then at right angles to the first direction to smooth out any inequalities in the coating. Place the paper to dry in a dark room free from dust. Quick, even drying is essential for brilliant prints. As soon as it is bone dry, it may be printed.

Printing. — The sensitive side of the paper, which is light yellowish-green in color, is placed in contact with the film side of the negative. The frame is put out in direct sunlight. Watch the progress of the printing until it is seen that the deepest shadows are bronzed and the halftones and some of the details in the lights are visible.

Developing. — The print is developed by placing it in running water, when it at once turns a brilliant

Prussian blue. Washing, to insure permanence, should last about half an hour. The print is then ready for drying, trimming, and mounting.

Varying the Color. — The blueprint can be brightened by treating the well-washed prints with a 2½ per cent solution of alum, a 3 per cent solution of oxalic acid, or a 1 per cent solution of hydrochloric acid. A blue-gray to purple tone is secured by the use of about 10 minims of ammonia water to a pint of water. As soon as the desired color is reached, bathe in alum, 120 grains; water, 16 ounces. Finally wash in running water for half an hour. Brown tones are obtainable by soaking the blueprint in stronger ammonia solution until bleached and then transferring to a saturated solution of gallic acid until the image reappears. The print is finally well washed and dried between blotters.

Printing-out Paper. — Although albumen paper can be obtained and sensitized by the worker as needed, and although it is a print-out paper, the term (abbreviated P. O. P.) is generally understood to apply to gelatine paper, such as Solio. The typical color obtained by gold toning is the so-called photographic brown, a combination of the red image with the blue of the gold. A somewhat less purplish tone is obtainable by working with a smaller quantity of gold. For instance, if 1 grain of gold in 12 ounces of water will tone ten 5 × 7 prints to a cold purple-black:

If diluted to 24 ounces, it will tone ten prints to a warmer purple tint;

If diluted to 36 ounces, it will tone sixteen prints to a brown tint;

If diluted to 48 ounces, it will tone forty prints to a red-brown or red tint.

This principle, of allowing a given amount of gold to a standard area of print and regulating the tone by changing the quantity of gold, has been applied as will next be shown.

Instantaneous Toning of P. O. P. — Four stock solutions are needed.

A. — Ammonium sulphocyanide	1 ounce
Water to make	10 ounces
B. —Gold chloride	15 grains
Water to make	7½ ounces
C. — Sodium phosphate	1 ounce
Water to make	10 ounces
D. — Saturated solution of borax.	

Mix, for toning ten 4 × 5 prints:

A	1 dram
Water	8 drams
B	4 drams
C	1 dram
D	2 drams

The prints, which should be only one shade darker than desired, are put directly into the toning bath without previous washing, one after the other, as rapidly as possible. On entering the bath, the prints turn red, but within half a minute they assume a beautiful dark purple tone, almost black in the deepest shadows. No matter how much longer they are left in, they will not change again. As soon as the prints have assumed a uniform color, they may be fixed, or, if preferred, transferred to a tray of clear water until the entire batch is ready for fixing.

Brush Toning. — This method of toning, like the preceding, uses up every particle of gold in the bath. It is therefore highly important to measure out the right quantity for the number of prints to be toned.

For instance, to tone four 4 × 5 or two 5 × 7 prints, measure out 15 minims of sulphocyanide, 120 minims of water, 60 minims of gold, and so on. To use such a small quantity to the best advantage, it is a good plan to lay the print face up on a clean sheet of glass and brush the toner over it with a tuft of cotton or a rubberset camel's hair brush, letting the surplus drip into a graduate. No matter how streaky the prints look at first, if the brushing is continued they will tone evenly and stop. Apparently they quickly absorb all the gold they are capable of taking up and thereby reach a very high degree of permanency. Prints toned in this manner have been exposed, half covered, to direct sunlight for three months without showing any dividing line.

Keeping Quality. — The stock solutions keep indefinitely, particularly if made up with distilled water and stored in yellow-glass bottles in a cool, dark place. The mixed bath will not keep more than an hour.

Economy. — Users of this method can easily calculate the exact quantity of each stock required for toning a print of a given size, check the figures by trial, and draw up a table showing how much to take for any number of prints. No gold is wasted, so it is extremely economical. It is simpler than other methods, as it requires no judgment. Still, if the P. O. P. worker prefers, he can follow the plan of using a bath of the strength advised by the maker of the paper and toning until the print has a particular color when looked through toward a window. The objection to this way is that prints are seldom uniform, as the strength of the light has a great deal to do with one's estimate of color. The instantaneous

method can be worked at night. For instance, one can print in the morning before going to business, store the prints in a light-tight box, and finish them in the evening.

Many readers of *American Photography* have written to the Editor that they have tried the instantaneous toner and found it to work perfectly. Beginners are earnestly advised to do their toning by the method just given until they become expert. Then, if they desire to secure other tones, they can experiment with different toning formulas, but we hope that no one will be unwise enough to use the combined toning and fixing bath and expect the prints to last. Remember that P. O. P. is permanent only if fixed as directed and then washed until the last trace of hypo is removed.

Directions for Fixing. — No matter what method of toning has been used, P. O. P. is generally fixed in a plain hypo bath containing 1 ounce of hypo in 20 ounces of water. Fixing requires from 10 to 20 minutes, and washing at least 12 five-minute changes or an hour in running water, keeping the prints well separated.

Special Toning Formulas. — A chocolate brown can be obtained in the following bath:

A. — Gold chloride	15 grains
Distilled water	60 ounces
B. — Ammonium sulphocyanide	1 ounce
Powdered alum	1 ounce
Ammonium carbonate	4 grains
Distilled water	23 ounces

Add 3 parts of A to 4 parts of B. The prints should be printed rather darker than if intended for ordinary

tones. For bright warm brown tones, take the same proportions as just given, only add water enough to make three times the volume.

There are many other special toning formulas, but each worker will find it easy to get almost any tone which P. O. P. is capable of yielding with those already given.

Homemade Silver Papers. — The amateur can sensitize pure paper of good quality, either rough or smooth, by "salting" it and afterward sensitizing it by floating on a solution of silver nitrate. Any of the drawing papers sold by dealers in artists' materials is satisfactory. A simple salting bath is:

Ammonium chloride	100 grains
Gelatine	10 grains
Water to	10 ounces

Swell the gelatine in a little cold water and dissolve it by warming gently on a water bath. Then add the chloride and make up to the required volume. The solution must be filtered into a chemically clean porcelain tray and the paper floated on it for three minutes, then dried in a warm, dark room while suspended by a clip from a line. The knack of floating the paper so as to avoid air bubbles is easily acquired if one holds the sheet in a U shape and lowers the loop until it touches, afterward lowering first one and then the other limb of the U.

Sensitizing, Printing and Toning. — The dried salted paper keeps indefinitely. When some is required for use, it is floated for a minute or two (depending on the roughness of the paper) on a bath containing 45 grains of chemically pure silver nitrate to each ounce of distilled water. Drying should be

rapid, say overnight in a warm, dark room. The paper is printed in the same manner as bought P. O. P., only somewhat deeper, as the image tends to " sink in " on account of there being no waterproof coating under the sensitive layer. Toning for warm sepias is in a gold bath. Blacker tones can be obtained in a platinum bath, as follows:

Potassium chlorplatinite	4½ grains
Water	10 ounces
Nitric acid	2 to 3 drops

Sepia Tones on Collodion P. O. P. — Although papers like Aristo Platino are intended chiefly for olive blacks by toning first in gold and afterwards in platinum, they will give very good sepias by gold toning alone. In fact, in the old days, before D. O. P. had become so popular, it was considered much easier to get the sepia effect on Aristo than on Solio. The directions which come with the paper are to be followed.

Self-toning Papers. — There are two classes of self-toning papers, gelatine and collodion. They correspond to the Solio and Aristo classes, but contain the gold needed to tone the image during the process of fixing. The fixing bath should be made alkaline by the addition of a pinch of baking soda, as acidity might cause sulphur to separate, thus causing sulphur toning and subsequent fading of the print. The tone yielded is a sepia or a somewhat chocolate brown. To get the " photographic brown," that is, the purple cast, it is necessary to treat the prints in a salt bath before fixing. The color, as with all other kinds of P. O. P., depends to a great extent on the negative. A thin, soft negative which prints quickly gives good

sepias and browns. A brilliant, dense, slow-printing negative is suitable for the purple tones. Indeed, such negatives used to be recommended for black tones in the days before the coming of Velox.

Toning Gaslight and Bromide Prints. — Many methods have been devised for converting the black silver image of developing-out papers to some other substance which shall be of a different color. In such papers, the image should consist of pure metallic silver imbedded in gelatine. Though this is theoretically true, in practice it is seldom that the image is free from other chemicals which play a great part in the results. The color of the silver deposit itself varies with the particular developer used, the amount of bromide in the formula, the condition of the solution, whether fresh and strong, or stale and loaded with oxidation products, and particularly the exposure, with its effect on the time of development. All of these influences alter the size of the silver particles and thereby change the color of the print. The individual variations of different brands of paper also greatly affect the handling, as some sorts work well with a given formula with which others yield only the most indifferent results. Thus, many formulas give splendid tones on bromide prints and extremely poor ones on gaslight prints. For this reason, it is well to warn the reader that he may have to try modifying his regular methods of working in order to get prints which will tone well.

Prints for Toning. — With most gaslight papers a reasonable adherence to the manufacturer's directions will produce good black and white prints, but unless their images are of the correct chemical quality their

color when toned may be poor. Assuming that fixing and washing are thorough, the general reason for failure lies in an incorrect combination of exposure and development. Overexposure must be avoided so that the print can be left in the developer until practically all the silver affected by light has been reduced. This means that the exposure must be practically correct in order that development shall be complete and stop for lack of reducible silver when the print is developed to the proper depth. Very evidently it is necessary to estimate the exposure with considerable exactitude when making prints for toning. Probably the best practical rule is that exposure should be such that development may be carried out for two to three times as long as normal for the paper in use. This time of development varies with different brands of paper and with different kinds of developers; consequently the first essential is to ascertain how long a given paper can be left in a given developer without fogging. To do this slip half an unexposed section of paper beneath the developer and watch it carefully. Remove it when the first signs of fog appear; fix as usual and then examine the two halves of the sheet. If there is any appreciable difference the time of development should be reduced somewhat and other strips used for tests. When there is no appreciable difference a trial print should be made and exposed as a test for the quality of the highlights. If they are of a satisfactory color the developing period thus ascertained may be used as a maximum for making prints for toning, using the particular combination of gaslight paper and developer employed in the experiment. For instance, we have found that one

make of paper in a metol-hydrochinon developer of given composition will produce a good black and white print if developed from 25 to 45 seconds, and that it can be left in the developer safely for 75 seconds when the print is to be toned. Generally speaking it will be found much easier to judge the correct depth of printing if one holds the print up and looks through it to the light. The blacks should be a full, dark black without any trace of gray. This appearance means that the silver has been fully reduced and is present in sufficiently great amount to stand the subsequent alteration of color without losing in vigor and weakening the print. In any event beware of examining the print in a weak or colored light as under such conditions it invariably appears darker than in daylight or strong white artificial light, so that when toned it will be too weak.

What Black to Work For. — The amount of bromide in the developer determines not only the color of the black and white print but also, to some extent, that of the toned print. If the developer contains a minimum of bromide, short exposure and maximum development tend to give blue-black tones, but longer exposure and minimum development, pure black tones; longer exposure and development in a more dilute and heavily bromided developer is productive of a warmer tone tending towards a brownish or greenish black; and still greater exposures with excessive bromide in the developer yield olives, browns, and reds. The blue-black and pure black tones yield a colder color in the toned print, the warmth increasing with the amount of bromide used in the development of the original black and white

print. To obtain a clean blue-black on papers capable of yielding such a tone (some are adapted only for warm blacks) one tries a slip of unexposed paper (in safe orange light, such as a lamp shaded with post-office paper or orange fabric) in the regular developer. If it fogs in the number of seconds needed to develop a print, enough bromide solution must be added to hold the paper clear during that time. Too much will cause the tone to be too warm. We might find with one brand of paper that 15 seconds gave a blue-black, 30 seconds a pure, neutral black, and 45 seconds a warm black; but whatever the time, adjusting the bromide in this manner will insure better tones than one gets when working solely by judgment. A trial print should then be developed to make sure that the whites are held clear and that the color is what is desired. Now, to make prints for toning, expose just long enough to secure the right depth by developing the paper 3 times the normal time.

Colors by Direct Development. — A few papers are capable of giving pleasing browns or sepias by overexposure and development in a special solution. The Kruxo formula for " sepias in first development " is:

Water	10 ounces
Eikonogen	20 grains
Sodium sulphite, anhydrous	300 grains
Hydrochinon	30 grains
Sodium carbonate, anhydrous	300 grains

For use, take 1 ounce of stock solution to 4 ounces of water and to each ounce add 1 drop of a saturated solution of potassium bromide. The prints should receive 5 times the normal exposure required by the

negative to give a black and white print in the regular M.-Q. developer. The prints develop slowly, so be careful not to take them too soon from the tray. They dry down decidedly darker. The color is controlled by the exposure and the amount of bromide. More bromide, longer exposure, and weaker developer give yellower tones. Little bromide, short exposure, and strong developer give browner tones, or warm blacks. In fixing sepias made by this method, it is important to dilute the regular acid hypo bath with half its bulk of water.

Other papers, notably Argo, in our experience, have a tendency to develop to coppery browns in a greatly-restrained developer, if overtimed, so we should expect the Kruxo formula just given to work well with them. The anti-friction developers seem to have more tendency to yield usable brown tones than the regular M.-Q. Many interesting variations of tone can be obtained by adding to the developer small quantities of 10 percent solutions of hypo, potassium iodide, and table salt — which chemicals, in about equal amounts, are used to prevent friction marks on glossy papers. To obtain good colors, the bromide should be in excess. No precise rules for all papers can be given.

Ammonium bromide is generally considered superior to potassium bromide as a restrainer for the particular purpose of getting colors on gaslight papers; but most of the formulas published in former years have been withdrawn by the manufacturers. We ourselves never succeeded in getting good results with them, and this seemed to be the general experience. Browns, especially, can be much more easily obtained with the

two sulphur toning processes, redevelopment and hypo-alum toning.

Redevelopment. — Metallic silver can readily be converted to brown silver sulphide by first converting it to a silver salt and then precipitating the silver sulphide through the action of any soluble sulphide. The one commonly used is sodium sulphide. Two separate baths are needed. The first forms silver ferricyanide in the print, and a typical formula is:

Water	64 ounces
Potassium ferricyanide (red prussiate)	220 grains
Potassium bromide	220 grains
Stronger ammonia water, U. S. P.	30–40 minims

The print, well washed to free it from every trace of hypo, is immersed in this bath and left until the last trace of black has disappeared from the deepest shadows. The next step is rinsing, which should be performed in running water, the only essential being to remove all traces of the bath from the surface of the print. It may then be put into the redeveloper, best made as follows:

Stock 20 percent sulphide solution	3 ounces
Water to make	20 ounces

The stock sulphide is made by dissolving the sodium sulphide, as soon as bought — rejecting any sample of the crystal form which has not a clear white color — in sufficient water to make a 20 percent solution. This should then be boiled in a Florence flask for about half an hour to insure keeping quality, allowed to cool, and made up to the original bulk with water. The boiling is not necessary, but it is a useful precaution and prevents one's using a weak or decomposed bath and thus spoiling the prints. The diluted

bath should not be saved for future use. Neither should the bleacher be overworked. If it does not remove the last trace of black in 2 minutes, take a fresh bath. The sulphiding bath should redevelop the picture to a rich sepia in from a few seconds to one or two minutes. If it does not, it is a sure sign of exhaustion. These two points will prevent all troubles not due to softening of the gelatine or impurities in the chemicals.

Prints for sulphide toning must be thoroughly hardened before redevelopment or they will soften and blister freely. It is wise in warm weather to dry the black and white print, soaking it in clean cold water for about five minutes before bleaching. Unless the standard acid hypo with alum has been used, it may be necessary, in warm weather, to give the prints a treatment with a solution containing from 2 to 4 percent of alum, after washing long enough to get rid of the hypo, and finally wash well to remove all traces of alum. Unless the hypo is completely eliminated, it will form with the ferricyanide of the bleaching bath a reducing agent (Howard Farmer's) and eat away some of the detail of the print. An hour in running water, keeping the prints thoroughly separated, is none too long to insure complete elimination of hypo. A good test for hypo is

Potassium permanganate.....	2 grains
Potassium carbonate.....	20 grains
Distilled water to.....	40 ounces

Take a little of this solution in a clean graduate and hold the prints so that they will drip into it. If the pink color is discharged and replaced by a greenish-yellow or a brown coloration, hypo is present, and the

washing should be continued until the drippings no longer cause any alteration in the permanganate solution.

Iron Spots. — As iron and ferricyanide solutions in combination form Prussian blue, the least trace of iron from the water pipes, as an impurity in the alum, or from a cracked enameled tray, will cause blue spots or stains in the print. The remedies are to use a filter on the faucet (a flannel bag will answer), secure pure alum, and paint the tray with one of the asphalt darkroom paints or tray enamels.

Commercial Redevelopers. — The smell of sodium sulphide is extremely unpleasant as well as somewhat dangerous. It causes depression, headache, and nausea. It also attacks and rapidly spoils all kinds of sensitive plates, films, and papers. It should, therefore, never be used in a workroom in which sensitive materials are stored. These disadvantages are so notable that several firms have put out somewhat less odorous sulphiding compounds. The Tabloid Sepia Toner contains a sodium salt of tin which is not only far less objectionable than the ordinary salt but gives better tones over a wider range of papers. The Odorless Sepia Toner of Johnson and Sons consists of a bichromate bleacher and a redeveloper which has only the faintest suspicion of smell. It gives excellent tones and keeps well in solution.

Saving Bad Sepias. — When, through neglect of the precautions already given for securing the best tone in the black image, the sepia obtained by redevelopment is too yellow, the print may be saved by bleaching in the darkroom in:

Copper bromide	130 grains
Sodium bromide	2½ ounces
Water to make	10 ounces

The bleached print is redeveloped in daylight with any clean-working developer, after which it may be retoned.

Formulas. — Although most formulas work well, many experienced workers believe that they secure an image more suited to redevelopment by the sulphide process by using amidol in the first development. We give herewith formulas which may be relied on in most circumstances.

Amidol for Gaslight Paper. — We have tried many formulas and prefer the following where rich, blue-black prints are desired. Overexposure gives disagreeable greenish tones. The developer must be prepared at the time of use.

Water to make	10 ounces
Sodium sulphite, anhydrous	250 grains
Amidol	50 grains
Potassium bromide	2 grains

Use full strength for hard-working papers. Dilute with an equal volume of water for soft-working papers.

Amidol for Bromide Paper. — Strong, rich prints on bromide papers can be obtained with the following:

Water to make	20 ounces
Sodium sulphite, anhydrous	325 grains
Amidol	50 grains
Potassium bromide	10 grains

The same formula, with more water, yields pure black to gray prints.

Bromide Solution. — A 10 percent solution of bromide is:

Potassium bromide	48 grains
Water to	1 ounce

Each minim (drop) contains $\frac{1}{10}$ grain. A saturated (65 percent) solution is

Potassium bromide	312 grains
Water to	1 ounce

Each minim contains 0.65 grain.

Recapitulation. — Good tones by redevelopment are obtained by using blue-black to pure black prints of considerable vigor. They must be exactly timed and fully developed. They must be completely freed from hypo before bleaching. The bleaching and toning baths must be fresh and strong.

Hypo-Alum Toning. — When an acid hypo bath is old or improperly mixed, so that sulphur separates from it and makes the bath milky, it has a decided toning action on the silver image. Observation of this phenomenon led to the use of alum to throw down sulphur and thus give a bath which would tone prints overnight in the cold or in half an hour when used hot, say about 110° F.

A typical plain formula is

Boiling distilled or rain water	128 ounces
Hypo	16 ounces
Alum	4 ounces

To ripen, add to the above when cool

Distilled or rain water	1 ounce
Silver nitrate	60 grains
Table salt	60 grains

The Artura Method. — One of the most reliable sepia-toning baths is that published for use primarily with Artura Iris; but it works well with other papers.

It is possible, with this formula, to get exactly the same sepia on both gaslight and bromide papers and to match the color of a carbon sepia print precisely. The prints need not be washed after fixing any longer than is needed to eliminate the acid from the fixing bath. Then tone as follows

No. 1. — Boiling rain or distilled water	128 ounces
Hypo	16 ounces
Alum	2 ounces
Boil two minutes	
Allow to cool and then add sodium phosphate	2 ounces

At this point test the bath with red litmus, which should turn blue within one minute. If it does not, heat the bath again and add hypo in 4-ounce quantities until it does. When a *slightly alkaline* bath is obtained dissolve

Silver nitrate	60 grains
Water	1 ounce

and

Potassium bromide	180 grains
Water	1 ounce

Pour the bromide solution into the silver solution, then add precipitate and all to the *cool* hypo-alum bath. If the silver and bromide are added to the bath while hot, it will turn dark. It is necessary to have the water at boiling point when the hypo and alum are being mixed. The other ingredients *must* be added at lower temperature.

No. 2. — Gold chloride	15 grains
Water	2 ounces

This bath must be neutralized with precipitated chalk.

The Toning Operation. — When ready to tone take

as many ounces of bath as are necessary for the number of prints and add 1 dram of gold solution (No. 2) to each 16 ounces of hypo-alum bath (No. 1). This quantity (128 ounces) will tone 1 gross of cabinet or 4 × 6 prints or the equivalent in other sizes. It is advisable to use fresh bath when this number of prints has been toned rather than attempt to renew its strength by the addition of gold. For a small batch of prints prepare a small bath. Preserve the same proportion of chemicals as advised in the above formula.

The entire lot of prints should be placed in the bath at one time, keeping them well separated during the process of toning. Tone at 120° to 125° F. Do not begin toning at a lower temperature than 120°. Thick rubber gloves are advised.

The time of toning should be about 20 minutes. The toning bath should be slightly alkaline. This can be determined by testing with litmus paper. If the bath is too cold the gold tone will predominate; if too hot, the sulphur tone will predominate. To determine when the prints have been toned, examine by transmitted light, and when all black has been removed from the deepest shadows, it is safe to assume that the final color has been obtained. Sponge prints to remove any sediment. Return prints for five minutes to regular fixing bath. Wash in the regular way.

Crimson Tones on D. O. P. — One of the most striking novelties at the photographic conventions of late years has been the rich crimson tone obtained on sepia prints by gold toning. The prints are sulphided in the hot hypo-alum bath given on p. 23.

When the prints have been toned and thoroughly washed, put them through a salt bath. The strength of the salt water may be about 1 to 32, but a little more or less salt will not injure the prints. Rinse in clear water and the prints are ready to tone.

No. 1. —	Water	15 ounces
	Gold chloride	15 grains
No. 2. —	Water	15 ounces
	Potassium sulphocyanide	90 grains

Add either one to the other, stirring the solution slowly, so as not to precipitate the gold. This 30-ounce bath will tone about 18 prints 8 × 10, or their equivalent. To strengthen this bath it is necessary to use both chemicals. Make stock solutions, No. 1 by dissolving 15 grains of gold in two ounces of water, and No. 2 by dissolving 90 grains of potassium sulphocyanide in two ounces of water. Add equal quantities of Nos. 1 and 2 to the old bath, the number of drams of each depending upon the number of prints to be toned. Using this stock solution avoids adding more water to the bath. Prints tone in about 10 minutes and should then be fixed in acid hypo for 20 minutes and washed.

Special Green D. O. P. — There are two special brands of gaslight paper which yield green prints direct. They are Artura Carbon Green and Kodak Velvet Green. The speed is so low that they must be printed by daylight (20 to 30 seconds near a north window) or 10 seconds 1 foot from an arc lamp. The rest of the manipulation is similar to that for other kinds of D. O. P. Slight changes in strength of developer and fixing bath are advisable; but they may be found in the direction sheets packed with the paper.

Other Colors by Toning. — We come now to a most fascinating branch of picture making, the securing of blue, green, and other colors on D. O. P. prints by chemical toning baths. It should be said at once that the success of the toning depends largely on the principles laid down already, namely that the image must be of a good black color, developed as far as possible, and quite black when viewed by transmitted light. Such a silver image will tone by almost any process, thus disposing of the trouble formerly experienced in trying to tone gaslight paper in bromide baths. An overtimed, underdeveloped black and white print will not yield good colors with any formula.

Copper Toning for Browns and Reds. — The range of tones yielded by copper is a wide one. The toner is cheap; it does not alter the vigor of the prints, and its results are permanent. Almost any shade from a warm black or dark brown to a pure red chalk can be obtained, the color depending on the length of time the bath is allowed to act. Two stock solutions are used.

A. —	Copper sulphate	60 grains
	Potassium citrate (neutral)	240 grains
	Water to make	20 ounces
B. —	Potassium ferricyanide	50 grains
	Potassium citrate (neutral)	240 grains
	Water to make	20 ounces

For use, mix equal parts. If the prints are pinkish in the highlights, use more citrate in either one of the stock solutions.

Bartolozzi Red. — C. Winthrope Somerville, F.R.P.S., gives the following process. Make up a saturated solution of ammonium carbonate by adding 3 ounces

of the crushed salt to 10 ounces of cold water, shaking as often as possible for several days. Make up the following solution in the order given.

Ammonium carbonate (saturated solution)...	1 ounce
Copper sulphate.....	10 grains
Potassium ferricyanide.....	25 grains

Any precipitate which forms when the copper is added to the carbonate will be redissolved. The solution should be perfectly clear, but should be used immediately, as it spoils on standing. Toning should be continued until the deepest shadow is converted and then for a minute longer. The print should then be washed for 10 minutes, or, preferably, immersed in the acid hypo bath to remove any unconverted silver salt and then washed. Pink stain in the whites is easily removed by treating with a 1 percent solution of ammonia water. If it is used stronger than this it will destroy the color.

Green Tones. — A process which gives considerable vigor by depositing a green color on the original black image is also given by Somerville. It gives an olive green.

Ferric chloride.....	1 grain
Oxalic acid, saturated solution.....	60 minims
Vanadium chloride.....	2 grains
Nitric acid.....	5 minims
Water to make.....	½ ounce

Then add, while shaking or stirring:

Potassium ferricyanide.....	1 to 9 grains
Water to make.....	½ ounce

The amount of ferricyanide depends on the paper used, some kinds requiring much more than others. Toning is complete in from 1 to 2 minutes. The longer

the toning, the lighter the green tint. Wash until the blue tint in the whites is gone and immerse in an acid hypo until the blue coloration is completely discharged. Then wash until the green color returns, which is a proof of the elimination of hypo. The best fixing bath is a 10 percent hypo solution containing 50 grains of boracic acid to every ounce of solid hypo.

Indirect Green Process. — Immerse the print in the following for 3 to 5 minutes.

Potassium bichromate	5 grains
Potassium ferricyanide	25 grains
Water	2 ounces

The longer the immersion, the lighter will be the green. Wash free from bichromate stain and tone in

Cobalt chloride	20 grains
Ferrous sulphate	5 grains
Hydrochloric acid	20 minims
Water	2 ounces

Toning is rather prolonged. Cobalt ferrocyanide is deposited on the black silver image, imparting to it a particularly fine shade of green.

If the hydrochloric acid is replaced by 30 minims of glacial acetic acid, an emerald green is obtained.

After toning, the print is washed for 5 or 10 minutes and placed in a hypo bath for about 1 minute and again washed. The result is quite permanent, even to 20 hours' washing.

If the cobalt chloride is replaced by 1 grain of vanadium chloride dissolved in an ounce of water and we add 1 grain of ferric chloride with 10 minims of nitric acid instead of the ferrous sulphate and hydrochloric acid, an olive green is obtained, the depth of

color depending on the extent to which the print has been bleached. There is, however, a slight risk of a continuing action which takes the tone up into the light-green stage if toning is not stopped soon enough.

A Non-poisonous Green Toner. — Mr. H. E. Smith is responsible for a formula which contains no poisonous chemicals.

A. —	Potassium ferricyanide	180 grains
	Distilled water	20 ounces
B. —	Vanadium chloride stock solution	3½ drams
	Ferric ammonium citrate (*green* scales)	45 grains
	Sodium citrate, neutral (Merck)	2½ ounces
	Ammonium chloride	90 grains
	Hydrochloric acid, C. P.	1½ ounces
	Distilled water	10 ounces

The stock vanadium solution is made by mixing 1 ounce of vanadium chloride, as purchased (Merck's syrupy), with 5 drams of C. P. hydrochloric acid and then adding distilled water to make 2 ounces, 90 minims in all. In making up the B solution, first add the hydrochloric acid to the vanadium solution. Then dissolve the ferric citrate, sodium citrate, and ammonium chloride in the 10 ounces of water and mix the two. The solution should be a dull mauve blue; not green — until mixed with A. Both A and B solutions will keep for months.

To mix the toning solution, take 1 part of A with 4 parts of water and, separately, 1 part of B with 4 parts of water. The two weak solutions when mixed together form the toning bath. Prints tone in from 4 to 8 minutes. Rock constantly, then wash in 5 changes of water, each of 2 minutes; give a bath of 1 to 50 hydrochloric acid for 2 minutes, and finally wash for 15 minutes in 7 or 8 changes of water. This

process does not intensify the print and the color is permanent.

Blue Tones. — Most of the blue-toning baths depend on the formation of Prussian blue by first converting the silver image to a salt and then forming the blue precipitate by means of iron. The most reliable formula, and one which is particularly effective for blue transparencies and lanternslides, is Kunz's modification of Somerville's formula, as follows. Bleach in

Water	10 ounces
Potassium ferricyanide	100 grains
Ammonia water 0.880 S. G.	100 minims

Wash well and tone in the following, rocking constantly:

Water	10 ounces
Ferrous sulphate	100 grains
Hydrochloric acid, C. P.	50 minims

Wash free from stain and fix in either the hypo with boracic acid given on page 29, or in a plain hypo with sodium bisulphite.

An alternative toning bath is

Water	10 ounces
Ferric chloride	220 grains

Blue with Intensification. — The direct process of blue toning is useful when prints lacking in vigor are to be toned.

Solution ferric ammonium citrate, 10 percent	2 ounces
Solution potassium ferricyanide, 10 percent	2 ounces
Solution acetic acid, 10 percent	20 ounces

The well-washed prints are immersed in this bath until the desired tone is reached, then washed well until the highlights are clear.

Blue Tones with Gold. — A blue-black to blue can be obtained by gold toning, the depth of the blue coloration depending on the time the bath is allowed to act. It is a useful process for saving rusty brownish or greenish enlargements.

Ammonium sulphocyanide	20 grains
Water	1 ounce

To which add

Gold chloride	2 grains
Water	1 ounce

after neutralizing the gold with precipitated chalk. The print is immersed in this bath and toned until the desired color is reached.

Purple-black to Red Chalk Tones. — A good copper toner which yields a pleasing variety of tones is

Copper sulphate	55 grains
Potassium citrate	500 grains
Water	9 ounces

Add slowly, while stirring

Potassium ferricyanide	45 grains
Water	1 ounce

In this bath, the toning may be stopped at any point by removing the print and washing well. If a sepia is desired, the print may be soaked for about 5 minutes in 2 percent nitric acid and washed. It may then be sulphided in the usual bath. The redder the copper tone, the redder the sepia. If, however, the print is simply toned in the bath as given, red tones may finally be obtained direct.

The Carbon Process. — One of the most reliable and beautiful of all printing processes, carbon, is particularly well adapted to making prints in colors.

There is commercially available a very large number of colored tissues, of tints of almost every known pigment which is capable of making a satisfactory monochrome picture and even tricolor red, yellow, and blue, for making photographs in the colors of nature. The photographer, then, having decided just what color he wishes, selects a tissue of that color and can print it with the certainty of getting perfect color, free from double tones and other defects which may interfere with results in any silver process. Furthermore, prints may be matched perfectly at any time by using the same tissue.

The objections to the carbon process are its supposed difficulty, its alleged high cost, and the necessity for double transfer if right and left are not to be reversed. Two of these objections are illusory. The difficulties are really slight and easily overcome. Print for print, carbon is not much costlier than other processes, because the waste is small and the chemicals used in manipulation are cheap. Double transfer need be done only when the picture shows such objects as street signs, the lettering of which cannot well be reversed.

Theory of Carbon. — Carbon printing depends on the property of bichromated gelatine to become insoluble in water after having been exposed to light. If the gelatine carries within its bulk a quantity of pigment, it is evident that pigment and gelatine will remain together wherever the latter has been rendered insoluble and will be washed off wherever the light has not acted, that is, under the highlights of the negative. The mixture of gelatine and pigment is spread on a supporting sheet of paper and is then called " carbon

tissue." It is, of course, printed on the surface of the mixture, and, as the coating is relatively thick, almost the entire image lies in the upper layers of the mixture and has nothing to attach it to the supporting paper after development. Accordingly, the image with a large part of the unaltered mass is transferred to a sheet of prepared paper and developed on that new support by washing away with hot water all the soluble gelatine with its enmeshed pigment. The result is that the picture remains on the new support. If the latter is a waxed " temporary support," it is easy to remove the picture, by means of a second transferring process, to a gelatinized " final support," which may be paper, wood, porcelain, or any other suitable material. Inasmuch as the image consists entirely of insoluble gelatine and pigment, the permanence of the print is as nearly absolute as can be secured.

So much for theory. Let us now take up the practical working of the process, stating it in its simplest terms so that its supposed difficulties, which are really mostly in the description, shall be minimized.

Sensitizing the Tissue. — Although sensitized carbon tissue can be bought, it must be used at once or it becomes insoluble even without being exposed to light. It is therefore considered better to buy the tissue unsensitized and prepare it for use only in small quantities just before it is needed. The older way of sensitizing was to immerse the tissue in a watery solution of potassium bichromate made alkaline with ammonia water. The only advantage was that the strength of the bath could be altered to adapt the process to soft or to hard negatives, the rule being that

the stronger the sensitizing bath, the softer the print. The practical limits were from 1 to 8 percent. For most work, however, a 4 or 5 percent bath answered well, particularly if a " carbon " type of negative was used. Such a negative may be described as one of rather more contrast than is desirable for P. O. P., one well-timed but not filled up in the shadows and having vigorous density in the lights. From such a negative, the carbon process is capable of producing a rich, brilliant print carrying every tone of the negative in its true relations to other tones. Carbon, in other words, is a long-scale process. The scale, notwithstanding, can be somewhat altered by changing the strength of the sensitizer. For this reason, it is well to keep on hand a 10 percent solution of potassium bichromate. Ammonium bichromate or sodium bichromate can be used instead. If the potassium salt is used, a part of the stock should be diluted to the required percentage for use and made alkaline by adding stronger ammonia water until its color changes from a reddish orange to a clear yellow.

Wearing rubber gloves to protect the skin from the action of the bichromate, one takes a sheet of the tissue and immerses it in the bath, swabbing it with a brush or a tuft of cotton to break up air bubbles and letting it lie face up until it is not only limp but begins to curl towards the back. As soon as this point is reached, the tissue must be removed, drained, swabbed, and hung up to dry in a dark place. The soaking averages about 2 minutes at ordinary room temperatures. The drying should be performed in a room free from the products of combustion of oil lamps or gas and should take not more than 12 hours.

The dry tissue must not be exposed to light except under the negative.

Spirit Sensitizing. — When a print is wanted in a hurry, the tissue may be sensitized as follows. Mix equal volumes of the 10 percent bichromate stock solution and alcohol. Wood alcohol will answer. So will denatured alcohol. Pin the tissue to a drawing board and apply the solution with a rubberset brush, making the strokes first in one direction, then in the other. Well done, this method of coating covers the entire surface quickly and evenly. Set the board up to dry (a fan is invaluable here) and as soon as the tissue is tacky, give it a second application of the sensitizer. As soon as the tissue is bone dry, it is ready for printing.

The Safe Edge. — Unless the negative is provided with a safe edge, the tissue may separate from its support. The rebate of the printing-frame is sufficient if a full-sized print is wanted; if not, strips of lanternslide binding must be pasted over the negative, or a cutout mask be used. A strip from $\frac{1}{8}$ to $\frac{1}{4}$ inch wide around the margins is all that is needed. This presents no difficulty to anyone who is accustomed to printing white margins on his postcards or prints.

The Actinometer. — The surface of the tissue being dark, it is not possible to judge the depth of printing by inspection. A simple gauge is a proof on P. O. P. Black or sepia tissue sensitized in a 5 percent bath takes about as long as a proof on P. O. P. from the same negative. However, one is more certain to get good results if each negative is marked on an arbitrary scale. One way is to expose a regular exposure meter, such as the Watkins or the Wynne,

noting the time to get a tint and (by experiment) the time of printing which gives a good result. For example, meter and frame are put out together and the tint is obtained in 15 seconds. The print is done in 4 minutes, 16 times as long. This negative, then, should be marked "16 tints" and, at any future time, printed 16 times as long as the time required to match the meter tint. A special print meter is furnished by Wynne. It consists of a negative bearing letters and numbers, each one located behind a hole in a metal plate. The holes are so graduated that each succeeding character takes ⅓ more exposure to render it visible in the proof on P. O. P. taken from the negative. A given negative is printed by experiment and the last number visible in the proof is noted at the expiration of printing. If the print is correct, the meter letter or number is marked on the negative. After a few have been gauged by trial, it is easy to estimate the right classification for other negatives. It is best to note the color of tissue used, for the light colors, such as blue, print much faster than reds, browns, and black. One doing much carbon or platinum printing can hardly afford not to own a Wynne print meter; but a suitable actinometer can be improvised by pasting strips of onionskin tissue to a glass, each step of one more thickness of tissue being marked with a figure. This scale is used with P. O. P., and the negatives are tested, as before, to find to what number the proof should be carried in order to yield a perfectly-timed carbon print. The exact form of the actinometer used, however, is of little importance, but some form should be used to avoid waste.

Printing. — Carbon tissue is printed in approximately the same time as P. O. P., but there is ordinarily no need to print in the shade, as is so often advised for the latter kind of paper. In the absence of daylight, either the Cooper-Hewitt mercury vapor or the ordinary arc light may be used; but only the strongest artificial illuminants are practicable. Should, however, a piece of tissue remain underprinted at the close of the day, it may be kept 12 to 24 hours before development. In this case, the continuing action of light will cause the tissue to become fully exposed, just as if printing had been normal. Correctly-timed prints, on the other hand, should be developed at once, to avoid the bad results of this property of the bichromated colloids.

Preparing for Transfer. — While the print is being made, a sheet of single-transfer paper (marked on the back with pencil) or the temporary support, well waxed, should be placed in a trayful of clear water to soak at room temperature. The surface has to be freed from bubbles, as air between the support and the tissue is the most fruitful cause of spoiled prints in this process. The paper should be about an inch longer each way than the print.

Transferring. — When the print is ready, it is removed from the frame and soaked until limp in the same tray with the support. Next it is carefully freed from bubbles and brought into contact, under water, with the support. The pigmented side of the tissue is brought against the gelatinized side of the transfer paper or the waxed side of the temporary support, as the case may be. Holding them together at one corner, the worker now draws them out with

the tissue uppermost and places them on the upturned bottom of a tray or on a sheet of glass for squeegeeing. The carbon squeegee is simply a strip of velvet rubber mounted in a handle. It is used with a firm but not heavy stroke from the center towards the four corners. The process of squeegeeing squeezes out all the air between the two sheets and secures perfect contact between the tissue and the support. If the contact is not perfect, the image may not adhere at certain points and a tear is the result. Tears and bubbles, of course, ruin the print; so the worker cannot be too careful about squeegeeing firmly and thoroughly.

The transfer is not complete until some minutes have passed. The easiest way to promote transfer is to hang the sheets by one corner from a line, allowing about 20 to 30 minutes, or until the edges of the transfer paper have begun to dry. By this time, the tissue will be sticking firmly to the support and the useless pigment can be removed in development without injuring the image.

Another way of transferring is to place the print on a sheet of plate glass, cover it with several thicknesses of photographic blotter, and put on another sheet of plate glass and any handy weights — sufficient to insure gentle pressure and firm contact. In either case, the softened surface of the transfer paper or the waxed surface of the temporary support adheres firmly to the image after sufficient moisture has evaporated to let the pressure of the atmosphere force the two surfaces into intimate contact.

Stripping. — Once the transfer is complete, the two sheets of paper are placed together in water at about 110° F. The exact temperature depends to a great

extent upon the make of tissue used. However, the hand is a fairly safe guide, as any temperature too high for comfort is also too high for any but grossly overtimed prints. The sheets are held under water until the pigment-gelatine mixture begins to ooze out everywhere. Then the tissue is stripped off, under water, and thrown away. The stripping must be done from one corner with one even pull, taking care that the transfer paper is kept under the surface throughout the operation in order to prevent streaks.

Development. — As soon as the paper backing of the tissue is removed, a slimy mass of gelatine and pigment appears. The picture is revealed by washing off the superfluous mass with the hot water. One can float the print face downwards or support it on a sheet of glass and dash the hot water on it with the hand. Local development with cooler or hotter water can be carried out, using a large syringe or a stream from a rubber tube attached to the faucet. Undertimed prints can be improved to some extent by using cooler water and overtimed ones saved by employing it at a much higher temperature. In fact, the process gives considerable latitude for saving incorrect exposures and modifying tones by local treatment.

Aluming. — When the print is developed, it is placed in a saturated solution of ordinary white alum, at room temperature, to harden the gelatine and remove the bichromate stain. After a short immersion, a few rinses in clear water are all that is needed to insure a permanent print. No injurious chemicals of any kind are left in the picture.

Double Transfer. — If the print has been developed on a temporary support, it is ready for retransferring

as soon as it it has been well dried. Whatever substance was used as the temporary support, it received a coating of wax, in order to allow the image to strip off readily when brought into contact with another surface having a greater adhesive quality. The waxing solution, by the way, can be bought ready prepared or made by the following formula

Beeswax	3 grains
Benzol	1 ounce

Dissolve and add

Resin	12 grains
Turpentine	1 ounce

The object of using benzol is to secure quicker evaporation of the solvents than if 2 ounces of turpentine were used, though the latter is satisfactory if benzol cannot easily be obtained. Simply allow at least an hour between waxing and using the support, if all turpentine is used.

Waxing. — Sprinkle a few drops of the waxing solution on a piece of Canton flannel and gently rub the surface of the support, using a circular motion from the edges towards the center. Then take a second piece of the cloth and polish lightly yet evenly in the same manner. The rubbing must be continued until all streakiness is removed and an even surface obtained. Then hang or set the support to dry in a place free from dust.

Forms of Temporary Support. — The surface of the finished print depends on that of the temporary support plus the texture of the final support. The paper usually sold is glossy and gives a somewhat shiny finish, but a perfectly matt surface can be obtained

by using ground glass or ground opal as the temporary support. A ferrotype tin, on the other hand, plus a very smooth paper, will give a glacé finish.

Final Support. — The paper which is to form the final support, in double transfer, has received a thick coating of hardened but not insoluble gelatine. A typical formula, applicable to any material which may be chosen to receive the image, such as ivory, china, glass, etc., is

Hard gelatine (Heinrich's)	320 grains
Distilled water	20 ounces

Soak for 4 hours; dissolve on a hot-water bath; then add

Chrome alum	12 grains
Distilled water	4 ounces

Unless the chrome alum solution is added slowly, with stirring, the gelatine may precipitate. The solution is filtered for use and flowed as thinly as possible over the surface which is to receive the print.

Final Transfer. — Whatever substance is to bear the image, it must be soaked in cold water for about an hour to swell the gelatine thoroughly and then in water at about 90° until the surface feels slimy to the fingers. Finally return the support to cool water and see that it is freed of air bells when needed for use. During the soaking, examine the prints on their temporary supports. When they have once become bone dry (to insure proper hardening), they may be soaked until limp and are then ready to transfer. The print is laid face upwards on a sheet of glass and the final support is brought into place and gently squeegeed into contact. Success depends upon the

drying together into one film of the soft gelatine and the low-relief image, the former moulding itself into the inequalities of the latter. Drying is performed by hanging the two sheets on a line. When they are bone dry, the temporary support can be started at one corner with the point of a penknife and will strip off cleanly and evenly.

Textbooks. — Readers who desire more complete information about the carbon process, including its use for lanternslides, transparencies, enlarged negatives, etc., can obtain from our publishers the ABC Guide to Autotype Carbon Printing, 60 cents, or Prof. E. J. Wall's "Carbon Printing," which is No. 8 of "The Amateur Photographer" Library and costs the same.

Ozotype. — Mr. Thomas Manly in 1904 introduced a modification of the carbon process under the name of ozotype. A print is first made on a special paper coated with a bichromate salt and a manganous salt. This gives a visible image, as in the case of P. O. P., and is simply washed and dried for use. The carbon tissue is prepared by soaking it for 1 minute at between 65° and 75° F. in the following acid bath.

Water.....	1,000 cc.	30 ounces
Glacial acetic acid.....	3 to 5 cc.	50 to 80 minims
Hydrochinon.....	½ to 2 grams	8 to 30 grains

When the minute is up, the print is also immersed in the bath, brought into contact, removed, and squeegeed in the regular way, then dried. Development is preceded by a half-hour soaking in cold water. Next transfer to hot water, forcibly strip off the paper backing of the carbon tissue, and lave in the usual way. The advantage of ozotype is that the image is not reversed, as the pigment is deposited on the

faint brown image formed in the first printing on the manganous paper.

Ozobrome. — Manly soon found that an image of silver and gelatine could be used instead of the special paper, allowing a bromide enlargement to be converted into an unreversed carbon enlargement; or a bromide print could be used for "printing" a number of carbons, which were then transferred to a suitable support and developed. He called this process ozobrome. Materials can be obtained from Messrs. Thos. Illingworth & Co., Ltd., Willesden Junction, London, N. W., England, who can furnish full working instructions. Ozobrome allows the use of any color of carbon tissue and can be worked at night, as the "printing" of the tissue is a chemical process not requiring the action of light, once the bromide print has been obtained.

Gum-Bichromate. — A process analogous to the earliest experiments in pigment printing which finally led to the carbon process is the gum-bichromate process. In its simplest form, a mucilage of acacia of U. S. P. strength, obtainable from the druggist, is mixed with an equal volume of 10 per cent potassium bichromate solution and a little moist water-color, ground in a mortar, and brushed over paper, which is then dried in the dark. Good coating requires some knack, as well as good brushes, particularly a large badger blender. The proportions of gum, bichromate, and pigment may be varied within wide limits, some formulas being better for detail in the shadows and some for gradation in the highlights. The most complete and authoritative information on the process is contained in a series of articles by Paul L. Anderson

which was published in *American Photography* from September, 1913, to February, 1914. Those who wish to avail themselves of the beautiful qualities of this medium, in any color which can be found in the lists of the makers of water-colors, should study carefully Mr. Anderson's articles.

Assuming the use of the simplest apparatus, the process is carried on as follows. The dried paper, if free from hairs and evenly coated, is printed under the negative about the same time as is required for a proof on P. O. P. The negative should incline rather to the thin side, one suitable for Regular Velox being about right. As soon as the paper has been exposed, it is immersed in cold water, freed from air bells, and allowed to float face down until developed. This may take half an hour or more. It is not advisable, under any circumstances, to brush the print. Experience in gum printing has convinced all workers who have met with success that the only way to get good prints is to coat again and print again — sometimes as many as four or five times. For this reason, each worker has ordinarily to find by experiment the right proportions of gum, sensitizer, and pigment to get the required gradation. Until Mr. Anderson's articles were published, no one had reduced the coating process to a formulary. We have, however, had good success with three printings of the same pigment, using very little pigment for the first coating and doubling the amount for each of the other two. The thin mixtures give more detail in the lights, when printed very deeply, and the heavy mixtures pile up the deposit in the shadows, particularly if the final printing is undertimed, so that light does not pene-

trate the highest lights of the negative, and accordingly the coating under them washes away. As a rough guide, we give the following data. Using smooth (hot-pressed) drawing-paper, take 1 dram each of mucilage and bichromate stock and about ¼ inch moist water-color for the first coating. This is sufficient for a sheet large enough to cut out two 8 × 10's. For the second coating, take ½ inch, and for the third, 1 inch of pigment. The first printing is about twice as long as required for a light P. O. P. proof, in order to fix all possible detail in the lights, though of course there is not enough pigment to give body to the shadows.

Registration. — One of the greatest difficulties in the gum process is to secure sharp registration. It is advisable to soak and dry all paper before coating, as this ordinarily takes out most of the stretch. Two pinholes at different points of the image are convenient guides. They may be made in some inconspicuous part of the film by means of an etching knife. Gum workers seldom print in small sizes, however, and for pictorial purposes a little unsharpness is not objectionable. One of the most attractive things about a good gum print is the effect of "running down," or slight blur due to the shifting of the gum in drying when a mixture rich in gum has been used.

Bromoil and Oil. — A method of making pigment prints in colors consists in inking up a swelled-gelatine photographic relief with a lithographic ink. Straight prints can be made by using an ordinary printer's roller, but the process, as practised by photographers, includes the use of a brush to apply the color, thus

allowing modifications to be made to suit the taste of the artist. In outline, the oil process is as follows.

A piece of double-transfer carbon final support paper is sensitized with the spirit sensitizer and printed under the negative until it begins to show the details in the highest lights. It is then washed in cold water until all the bichromate stain has been removed and given a rinse in warmer water, until it begins to feel slimy. The unexposed margins which have been protected by the rebate of the frame form a safe edge which should be used to test the degree of swelling of the gelatine. In some cases, the relief is plainly visible when the print is viewed from the side, looking across it at a slight angle. If the relief is not great enough, it may be increased by using hotter water or a very weak sulphuric acid bath. Whatever the time required to get good relief, it is useless to begin inking up until the gelatine has absorbed all the water it can hold. When this occurs, place the print on a number of sheets of wet blotter supported on a sheet of glass and remove all droplets from its surface by means of a piece of cheesecloth. On no account must any dust or lint be allowed to collect on the surface.

A bit of lithographic ink about the size of a pea is now squeezed from its tube (assuming the use of Sinclair's colors) and spread on a sheet of glass by means of a palette knife. The brush, a stag's foot, is now inked by pressing only the tips of the hairs against the ink. When it is well charged, begin to ink up the picture at one of the upper corners, using a firm stroke which comes practically all from the wrist and allowing the ends of the hairs to touch the paper

without flattening out appreciably. The knack is soon acquired. The ink adheres to the wet gelatine in proportion to its content of water. Too stiff an ink, or too much force in applying, may cause even the highlights to retain the ink. In this case, a minute amount of liquid megilp, or Robertson's Medium, may be mixed into the ink by means of the palette knife. Once the right consistency of ink is found, the whole picture is rapidly inked up. Should the highlights now need to be brought out, ink can be removed by using a dry " hopping " brush, which is a small stag's foot brush supported in a wire handle so that it can be used to give a succession of light, quick blows on the paper, thus picking up ink. The brush has to be cleaned from time to time by wiping the tips of the hairs on a bit of cloth moistened with gasoline. On the other hand, if the shadows are not dark enough, a little stiffer ink can be used and more color be loaded on to them; or the hopper can be used to bring out details. Similarly, an obtrusive high-light can easily be darkened or even removed by judicious application of thin or of stiff ink.

Each worker generally finds it advisable to adopt some particular procedure which adapts itself readily to his manipulation. More can be learned by experiment than by following directions which may suit the writer of them but not be fitted for the reader. Varying the consistence of the ink and the character of the stroke will enable anyone, with practice, to deposit or remove ink at will. In this manner, alterations are readily carried out, often resulting in greatly improved pictorial quality.

Bromoil. — In order to avoid the necessity of sun printing of the bichromated transfer paper, bromoil was invented. The principle is that the gelatine of a bromide print, after removal of the silver image, acts as a gelatine relief and takes the ink in proportion to the amount of silver which was deposited. An ordinary bromide print, either contact or enlargement, is bleached, fixed, swelled, and dried. It is then soaked up and inked just as if it were an oil print, and finally dried. It is best to dry the prints by pinning them to a board, as litho inks often take several days to dry, and the print must be kept flat. Mounting is best done with shellac or dry mounting tissue.

Bleaching. — A great many formulas for the bleaching bath have been published, and all of them will work well with some papers; but there seems to be a certain amount of difficulty in getting them to work uniformly with other kinds. The following formula, however, has the advantage of not requiring a separate treatment with acid to prepare the bleached print for inking up.

Copper sulphate	40 grains
Sulphuric acid	2½ minims
Potassium bromide	40 grains
Potassium bichromate	3½ grains
Chrome alum	8 grains
Water to make	10 ounces

Bring the bath to about 90° and immerse the dry bromide print. Bleaching takes about 5 minutes, until only the faintest trace of an image remains.

Washing. — The bleached print is now well washed in running water for about 5 minutes to insure removal of traces of the bleaching solution and then fixed.

Fixing. — If any silver is left in the print, it will in time darken under the influence of light and alter the gradation of the final image or stain the lights. Either plain hypo or the usual acid bath may be employed, though all English workers recommend the use of the simple hypo and potassium metabisulphite bath. Our own preference is for this, or Lumière's liquid bisulphite, as the acid clearing and hardening agent, as neither of these substances, in the absence of alums, shows any tendency to decompose the hypo and throw down sulphur. The standard bath is

Hypo	1 pound
Water	4 pints

Dissolve and add

Potassium metabisulphite	1 ounce
Water	1 pint

Two or three ounces of liquid bisulphite (Lumière's) can be substituted for the metabisulphite with equally good results. Either agent hardens the gelatine without that excessive tanning action of alum or chrome alum which prevents after-treatment. Fixing should last about 10 minutes for heavy papers and should be followed by the usual washing.

Drying. — At this stage, many failures can be prevented by drying the prints, though it is quite possible to ink them up as they come from the wash-water, because they have already been thoroughly swollen and prepared for the inking. However, it is safer and often more convenient to prepare a batch of prints on one occasion and do the inking on another evening, and drying may forestall failures.

Soaking. — Presuming that the bleached print has been dried, put it into clear water to soak and add

hot water a little at a time until the bath reaches about 90°. The print is then put on wet blotters and inked precisely as in the oil process.

Glue Mounting. — A method of securing flat prints which is worth a trial is to mount them on glass, as soon as inked, using liquid glue and attaching them by the edges only. The best way is to mark out the size of the print on the glass, apply a line of glue, and then put on the print, pressing down the edges only. When perfectly dry, the print can be trimmed *in situ* with a straightedge and a sharp knife. Fuller details of these processes are given in Mortimer and Coulthurst's "The Oil and Bromoil Processes," obtainable from our publishers, price 60 cents.

Color Photography. Autochromes. — On a commercial scale, the only thoroughly successful method of color photography introduced up to 1915 was the Lumière Autochrome. Other processes of making screen-plate color transparencies on glass have been brought forward, but they have not succeeded in winning for themselves so secure a place. The Auto-chrome, for one thing, is far easier to handle than any duplicating method, as there is no room for error in the density of the positive. Although its color rendering is not absolutely perfect, in all circumstances, it does give with ease and certainty a pleasing rendering of Nature with freedom from any predominating tinge of blue or green. Incorrect exposure, of course, may introduce too much density (underexposure) or a prevailing pink tone (overexposure); but a properly-timed plate will yield a remarkably faithful and beautiful result.

Autochrome Exposure. — The most vital part of the entire process is the securing of correct exposure.

It was soon found to be quite useless to attempt to make Autochromes without the guidance of a good meter. The Watkins Color Plate Meter, the Wynne with special scales, or any other designed particularly for this use may be employed with satisfaction. It is not possible to rely on ordinary methods of calculating exposure, for Autochromes (and color-sensitive plates requiring deep screens) do not follow the usual rule that exposure is inversely proportional to intensity of light. Watkins found that when the light decreased 64 times the exposure increased 128 times, instead of 64 times, and this allowance is made on the scales of the Color Plate Meter. Furthermore, when the light-value or actinometer-time is taken in minutes and the exposure is also read as minutes, the speed of the plate has to be taken at half its usual value. At the present time, 1916, the speed of the Autochrome plate is Watkins 4, equivalent to Wynne F 14 or American Photography Exposure-Tables 7½. The procedure which has invariably yielded perfect exposures is as follows. Hold the meter at arm's length and view the darkening paper through half-closed eyes. Time the darkening accurately with a watch or by means of a half-second pendulum. Take the exact number of seconds needed to match the tint, particularly when it comes between the numbers stamped on the rim of the meter, as the latitude of the plate is very small. Test the *best* light, full sunlight or skylight, as the case may be. If the subject is one having shadows near the camera, take the sunlight time but give 50 percent more exposure. This is equivalent to taking the average between the sunlight and shadow tests. For snow scenes, divide the indicated exposure by 4

for open snowscapes with no near dark objects or by 2 for those having, for instance, evergreens in the near foreground. As overexposure is the error which affects Autochromes most adversely, do not exceed the times figured for full tint and best light.

Exposures indoors are calculated by making the test in the spot where the subject is, taking the plate speed as 2 if the actinometer time is 1 minute or more. If *f*: 8 or smaller is used, the camera exposure will always be longer than the actinometer exposure, so they can be started together.

The exposure of color plates is always through a yellow filter to get rid of a proportion of the blue rays in ordinary daylight. An accurate worker will have a morning and an evening filter, since blue predominates before noon and especially in the early morning, and yellow in increasing proportion as the daylight fails. With snow subjects a slightly deeper tint of yellow is indispensable. This screen may be attached to either the front or the back of the lens. Some prefer to have a cell containing it to screw on the lens front, but some cameras are not so well adapted to this plan as others. There is no occasion to worry about drawing out the camera to compensate for the thickness of the filter if the ground glass is reversed. The plate must be put into the slide in perfect darkness, the glass side facing the camera. A piece of black or white card is placed next the film to prevent its being scratched by the springs, white card allowing slightly shorter exposure than black.

Development. — Having taken your photograph you will proceed to the darkroom. As Autochrome plates are sensitive to all colors, including red and

yellow, the ordinary darkroom lamp will be worse than useless. But it will require a good deal of practice in getting the exact exposure to warrant one in developing by time only and in the absolute dark. There are two ways of getting out of the difficulty. The first is by having fitted to the dark lantern a green and yellow filter paper or glass (Lumière Virida), which may be obtained of the proper tint from any dealer; the second — which we prefer, not only for tyros, but for the general photographer, who is never the worse for seeing what he is doing — is to desensitize the plates by Mr. Hitchin's solution, which is simpler and more reliable than any other we have tried. It is prepared thus:

Potassium metabisulphite	3 grains
Rain or distilled water	1 dram

The Autochrome plate after exposure must be plunged into this solution in the dark and kept in it for 3 minutes, taken out, rinsed, and may then be developed by a deep yellow or red light.

Metoquinone Developer. — The developer recommended by Messrs. Lumière is made up from the following stock solution, which is to be diluted with 4 times its bulk of water for use. If the user does not care to make it himself it is supplied ready prepared.

Water (distilled if possible)	3 ounces
Metoquinone	3½ drams
Sodium sulphite (dry)	3 ounces
Ammonia (sp. gr. 0.923, 22° Baumé)	1 ounce
Potassium bromide	1½ drams

Dissolve the metoquinone first in hot water, then the other chemicals in the order given. When exposure

is known to be correct, development should be for a fixed time, and for this purpose six drams of metoquinone stock solution are diluted with three ounces of water to develop a 5 × 7 plate. The plate should not be exposed to the bright light of the darkroom lantern even if the Virida safelight is used, until development has proceeded for at least twelve seconds, when it may be examined rapidly to make sure that it is evenly covered by the developer. Development will be completed in exactly 2½ minutes if the exposure is correct, and the temperature of the developer is kept at about 60° F. The makers' manual gives instruction for controlled time development to allow the correction of errors of exposure, but the results are not as satisfactory as if correct exposure is originally obtained. It is therefore best in most cases to develop for a fixed time, though it is not absolutely necessary to use the metoquinone developer.

We have used with great success the Burroughs Wellcome " Tabloids " of rytol as well as many other developers. Any good developer will answer if it works perfectly clear and the correct time for the temperature is known. For instance, we have obtained perfect results by using a concentrated D.–Q. developer for ⅜ longer time than needed for ordinary film at the same temperature — 8 minutes instead of 5 at 60° for Modified Thermo D.–Q., S dilution. The figures for other temperatures are: 65°, 6¼ minutes; 64°, 6½ minutes; 62°, 7⅓ minutes; 60°, 8 minutes; 58°, 9 minutes; 56°, 10 minutes; 54°, 11 minutes; 52°, 12 minutes, and 50°, 13½ minutes. The developer should never be used warmer than 65° unless the plate is given a preliminary bath in diluted formalin, or it will

frill. The times for "Tabloid" rytol, one pair to each ounce of water, are: 65°, 6¾ minutes; 60°, 8 minutes; 55°, 9½ minutes. For full details of Thermo development, see the American Photography Thermo Development Card, price 25 cents postpaid.

The plate may be handled in safe green light (Lumière Virida papers) or total darkness and developed in a covered tray for the proper time. The developer is then poured off and the tray filled with water once or twice.

Reversal. — Now pour over the plate a freshly-made and filtered solution of acid permanganate, mixed according to the Lumière formula, or acid bichromate, made by the following formula, or more conveniently, "Tabloid" reversing compound.

Water	35 ounces
Potassium bichromate	75 grains
Sulphuric acid	170 minims

As soon as the plate has been flooded with the reverser, turn on the white light or take the tray to an open window where strong daylight can fall upon it. The silver image is completely dissolved in from 3 to 4 minutes. At the end of this time, pour off the reverser and rinse until the water is no longer colored.

Second Development. — If the Lumière metoquinone developer with ammonia was used and poured into a graduate, it will by this time have lost most of its alkali (ammonia) and can be used for the second development. Otherwise, we prefer dianol, according to the following formula:

Distilled water	35 ounces
Sodium sulphite, anhydrous	220 grains
Dianol (or amidol)	75 grains

The second development is carried on by full daylight or strong artificial light until the yellow silver bromide left after reversal has completely blackened. Four minutes is not too long a time to allow. The color transparency is now ready for a brief rinse and can be set up to dry without fixing or prolonged washing.

Drying. — The plate should be dried within half an hour. Keep it in a draft in a warm, dust-free place. It is necessary to touch a bit of blotter to the lowest corner from time to time to remove the drop of water which collects, or it may work in between the film and the layer of starch grains and dissolve some of the green dye. As soon as the plate is dry, it should be varnished with the special Autochrome varnish, which is gum dammar dissolved in benzol. The picture is finished by matting and binding up with a cover glass just as if it were a lanternslide. Autochromes are seen to the best effect if projected on the screen or viewed in a diascope by reflected light from the blue sky or a white cloud. They should be protected from strong light when not in use, as the colors gradually fade. Still, a well-made Autochrome should last many years unless recklessly exposed. More complete directions are given in " Color Photography with Autochrome Plates," distributed free by the makers of the plates.

Utocolor Paper. — The demand for color photographs upon paper instead of transparencies on glass led to the production of Dr. Smith's Utocolor paper for printing from Autochromes. Exposures are made by daylight, using colored filters during the printing, and the pictures reproduce the originals with approxi-

mate accuracy. The process, notwithstanding, is not sufficiently perfect to be of more than passing interest. Autochromes can be reproduced on a commercial scale by three-color halftone printing, though the cost is, naturally, high.

The Paget Process. — This, like the Lumière, is a screen plate process; that is, the separation of color into its components is effected by means of a special screen plate, carrying a pattern ruled with squares of green, red, and blue. This method of making a screen plate has the advantage that any number of screens can be made, absolutely identical, and corresponding viewing screens can also be made in any desired quantity. With one taking screen any number of negatives can be made, and from these any desired number of positives can be prepared, each of which can be bound up with a viewing screen, thereby making an indefinite number of identical transparencies of a subject. The plate used in the process is a special panchromatic plate, and cannot be replaced by any other. It is placed in the plate holder with a taking screen in front of it, film to film, and as absolute contact is essential, if the plate holder has no spring, a piece of clock spring may be used behind the plate. A special yellow filter is also required, and is usually a piece of stained gelatine placed between the cells of the lens. Exposure is made with an ordinary camera, the speed of the plate with filter being Watkins 11, equivalent to 6 in the *American Photography* Exposure Table. This is considerably faster than the Autochrome, which is rated at Watkins 4 or *American Photography* 7½. After exposure, the plate is developed with rodinal, or a special developer fur-

nished by the Paget Company. It can be developed with a developer which brings out the shadows quickly without making the highlights too dense. This negative being made upon a panchromatic emulsion with a color filter, is also perfectly corrected for color, and may be used for ordinary black and white printing, giving usually much more beautiful prints than are likely to be obtained with ordinary plates.

For colored pictures, transparencies are made on a special transparency plate, using rather short exposure and vigorous development to obtain a brilliant positive. This positive when dry is bound up with a viewing screen, some little practice being required to get exact register. If this is not obtained, false color, or diffraction or parallax effects may be obtained. By altering the character of the positive, considerable latitude for correction of errors exists. Generally speaking, the color rendering tends toward bluish or greenish tones, and is not quite as satisfactory as that of the autochrome, but Paget lanternslides are much more transparent than autochromes, and an indefinite number of prints can be obtained from a negative, so that the process is both popular and useful.

The Kodachrome Process. — In 1915 the Eastman Kodak Company introduced in a limited way a process of portraiture in color, called Kodachrome, which depends on separation into two colors only, green and red. It is obvious that violets and blues cannot be truthfully rendered by this process, but this is not especially important in portraiture. The resulting pictures are positives on glass, adapted to be viewed by artificial light, and they are generally displayed in special frames with an appropriate electric illumination

behind them. Under these conditions the rendering is extremely artistic and the process gives most beautiful results. It is unnecessary to give details of the manipulation here, as a special and rather expensive outfit is required for working the process, and full directions are furnished to purchasers.

Prints in Colors on Paper. — Many processes have been proposed for making prints in color on paper. In theory the problem is not especially difficult and numerous methods have been worked out by ingenious inventors. A number of these have been tried out in practice and some of them have proven perfectly workable from the standpoint of the experimenter. They have mostly proved failures, however, as commercial processes, because the initial outlay on a color photography process is large and a very large volume of sales is necessary in order to give enough profit to cover the experimental costs as well as pay an adequate return on the investment. Up to the present time the processes have been so involved that they were beyond the reach of the average amateur photographer, and the sale has not been sufficient to justify the continued production of the sensitive material. There are, however, certain processes which have proved practical successes and which can be worked by anyone who has sufficient interest and technical skill. Materials for these processes can be obtained at the present day. They are not for sale in the United States, as a rule, but would have to be imported specially.

The Sanger-Sheppard process consists in making three separation negatives through appropriate color filters, printing positives on carbon tissues of ap-

propriate colors, and squeegeeing them into contact. Prints of this nature have been sold commercially by various portrait photographers and are still made in some studios.

The German Pinatype process is also still used, producing its results by selective staining. Another German process wnich has been recently introduced, is known as Uvachrom. This is being extensively worked in Germany at the present time. This is an imbibition method, prints from the three separation negatives being without color when made and getting their color by soaking in appropriate dye solutions. This process makes very beautiful lantern slides and is also used for interesting prints on paper.

The Future of Color Photography.—Many inventors are working continually on processes for motion pictures in color. The problem here has not been theoretically difficult as far as the prodution of colored results are concerned, but the production of three images which will exactly superimpose demands such complicated taking and projection apparatus that most efforts are for the production of a compromise, using only two exposures and consequently giving a color result which must be nore or less untruthful. The experimental results in many of these processes are very beautiful, but doubt still exists as to their commercial practicability.

It does not seem to us that there is in sight any prospect of a process for producing natural color prints which would be simple enough to be worked out by everybody, as in ordinary photo-

graphy. The results also, we are afraid, would not be on the whole as satisfactory as black and white prints, for the handling of color Harmonics is so much more difficult than that of ordinary compositions that the percentage of artistically satisfactory results would probably be very much less than is the case in ordinary photography. There are some who argue that the general practice of color photography would tend to educate the eye for color. Whoever sees thousands of amateur prints and notes how enthusiastically the average snapshotter and onlookers applaud a picture which violates every law of composition, and is absolutely untruthful in its rendering of values, exaggerating delicate tonalities into excruciating contrasts of black and white, will hardly be inclined to agree with this view. For the present therefore, the production of photographs in natural colors, except by the Autochrome process, is not likely to come within the range of most amateur photographers.